EE 331 LAB 7: RC/RL TRANSIENT RESPONSE

Name:______________________ Section:__________ Date:________________

OBJECTIVES:

1. Make measurements on a simple RC circuit.
2. Plot the exponential curve for the voltage across a charging and discharging capacitor.
3. Make measurements on a simple RC and RL circuit to observe the behavior of a capacitor with a square wave input.

REFERENCES:
(a) *Core Course Laboratory Manual*, 1999
(b) Hambley, *Electrical Engineering Principles and Applications*

EQUIPMENT:

Resistors:	1 kΩ, 10 kΩ, 220 kΩ, 330 kΩ,
Capacitors:	0.1 µF,100 µF
Inductors:	470 mH

SIGNALS: None

PROCEDURE:

1. Equipment setup:

a. Turn your oscilloscope ON to let it warm up.

b. Function generator Set-up. The Function Generator will be used as the source input to the RC/RL circuit in Part 4. Turn ON the function generator and the frequency counter. Set up the Function Generator in its basic mode as follows:

- All the push buttons in the **MODULATION** section should be in the **OUT** position.
- The thin blue push buttons on the **OFFSET** and **SYM** controls should be in the **IN** position.
- Turn the **TRIGGER PHASE** to the **FREE RUN** position.
- The **SQUARE WAVE FUNCTION** should be pushed **IN** with the other two FUNCTIONS in the **OUT** position.
- The **AMPLITUDE** control should be on the **10 Volt range** and the center knob set at maximum (fully CW).
- PUSH IN the **RANGE** button for 1k Hz. This allows the frequency to be varied from about 100 Hz to about 13 kHz by turning the FREQUENCY knob.
- Set the **FREQUENCY** knob to 1.

2. Measurement of Component Values :

a. Measure the resistors and the inductor resistance with the DMM and record the values in Table 1.

b. Measure the capacitor and inductor values with the LC meter. Your instructor will demonstrate the use of this instrument. It must be shared because there is only one of these per lab. Enter the values in Table 1.

	Nominal Value	**Measured Value**	**% Difference**	**Within Tolerance?**
$\mathbf{R_1}$	330 kΩ			
$\mathbf{R_2}$	220 kΩ			
$\mathbf{R_3}$	1 kΩ			
$\mathbf{R_4}$	10 kΩ			
$\mathbf{C_1}$	100 μF			N/A
$\mathbf{C_2}$	0.1 μF			N/A
$\mathbf{L_1}$	470 mH			N/A
$\mathbf{R_{L1}}$	550 Ω			N/A

Table 1

3. Measure the Transient Response of an RC Circuit.

a. Build the circuit shown in Figure 1 on your QUAD board. **Be sure to install the capacitor with the correct polarity as shown!**

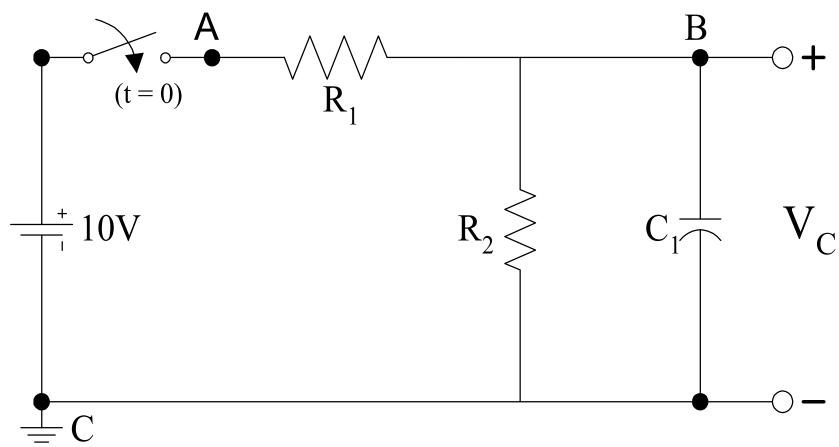


Figure 1

b. VIP the circuit in Figure 1. Note the value you calculated for $\boldsymbol{\tau}$ and $\mathbf{V_C(t)}$ from your Prelab.

$\tau =$ ___________ $\mathbf{V_C (t) =}$ ________________________

c. Set the DC power supply to 10 Volts as measured by the DMM.

d. Using a watch, record (to the best of your ability) the voltage across the capacitor at the time intervals appearing in Table 2. The switch is closed at t=0. Use a jumper cable as the switch. It might be a good idea to make a test run before recording the actual values. Remember to fully discharge the capacitor with a shorting bar between each run.

Time	0	5	10	15	20
V_c (exp)					
V_c (prelab)					
Time	25	30	35	40	45
V_c (exp)					
V_c (prelab)					
Time	50	55	60	65	70
V_c (exp)					
V_c (prelab)					

Table 2

4. Measuring the RC Response to a Square Wave Input:

a. In this section of the lab, you will use the function generator to input a square wave of two different frequencies and observe and sketch the output waveform measured across the capacitor. b. A schematic diagram containing the AC voltage source is shown in Figure 2. Build the circuit of Figure 2 on the QUAD board with $R_3 = 1\ k\Omega$ and $C_2 = 0.1\ \mu F$.

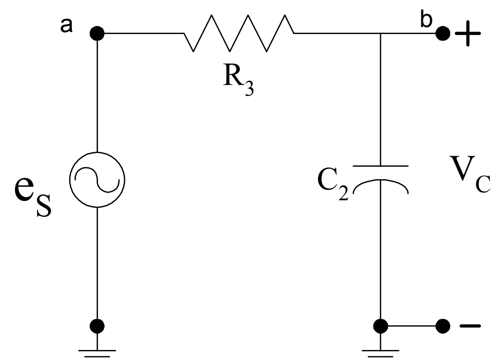


Figure 2

b. VIP the circuit in Figure 2. Use a square wave input as the input voltage source with a frequency of 500 Hz and 4 volts pk-pk. Display this signal on Channel 1 of the oscilloscope. Display $v_C(t)$ on Channel 2 of the oscilloscope.

c. Put the "Channel Coupling" switch to "DC" for both channels. We will add a DC component to the square wave so that the square wave goes from 0V to 4V. This will simulate a switch being closed and opened. Find the "offset knob" on the function generator and push the blue button until it pops up. This enables the offset. Adjust the knob by adding a "DC Offset" until the bottom of the square wave touches the center horizontal line on the oscilloscope. The display on the oscilloscope should look like the bottom waveform shown in Figure 4 of the prelab.

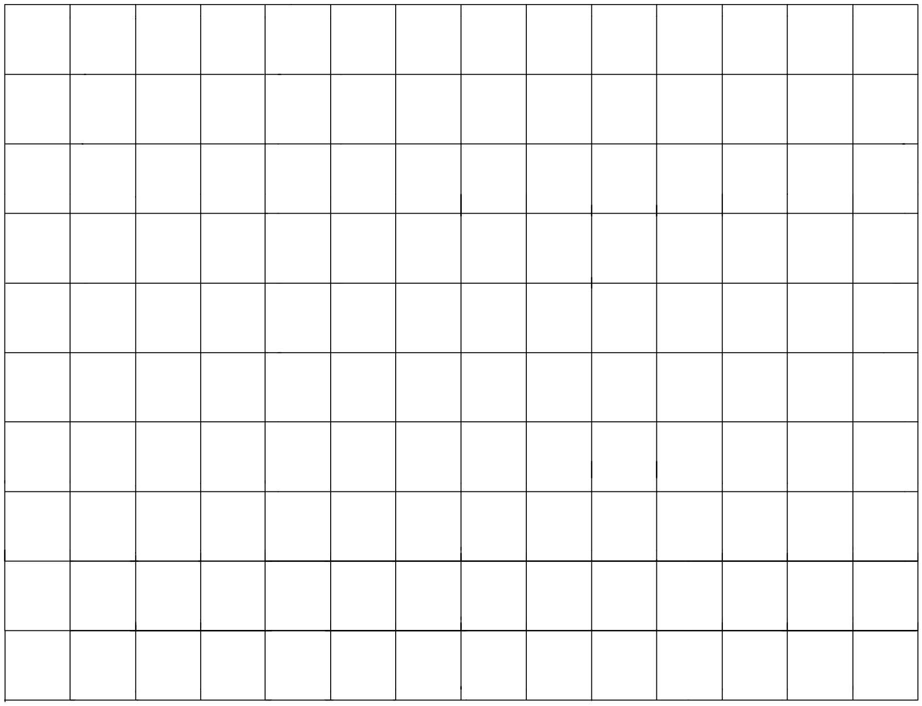
d. Measure v_C at each multiple of the "charging" cycle shown in Table 3 from Channel 2 of the oscilloscope. Use the value of τ determined in your prelab. Record your values in Table 3. You may need to adjust the time scale in order to make precise measurements. Carefully graph one full cycle of both waveforms on Graph 1.

e. Change the frequency of the square wave to 4 kHz. Record the values for voltage in Table 3. Carefully graph one full cycle of both waveforms on Graph 2.

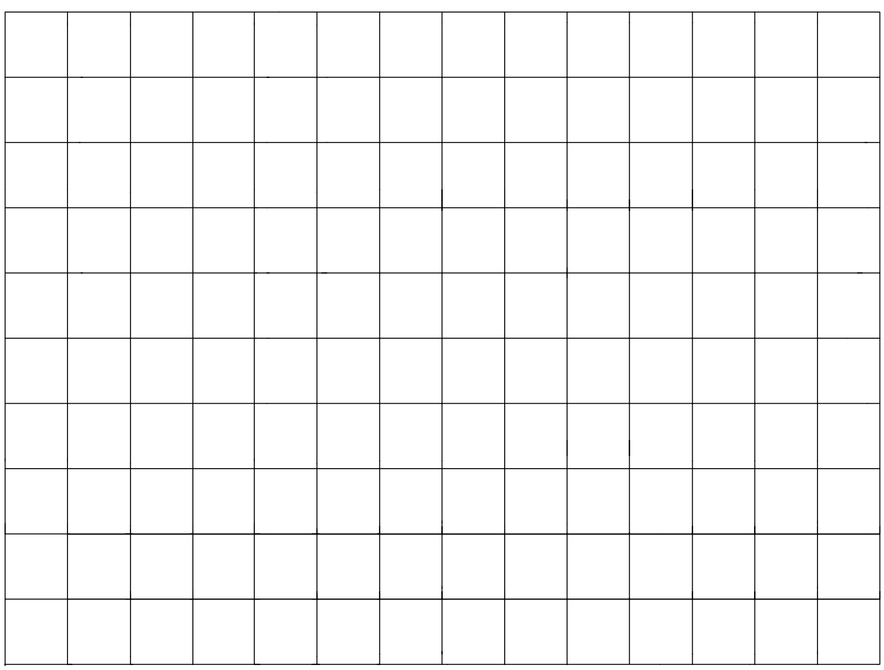
$v_C(t)$ @	τ	2τ	3τ	4τ	5τ
500Hz					
4 kHz					

Table 3

g. Carefully plot one full cycle of $e_S(t)$ (CH 1) and $v_C(t)$ (CH 2) on the graphs below for each frequency on the graphs below. Label both axes and include proper units. Number both axes at each division.



Graph 1
(C= 0.1µf, freq = 500 Hz)



Graph 2
(C= 0.1µf, freq = 4 kHz)

5. Measuring the RL Response to a Square Wave Input:

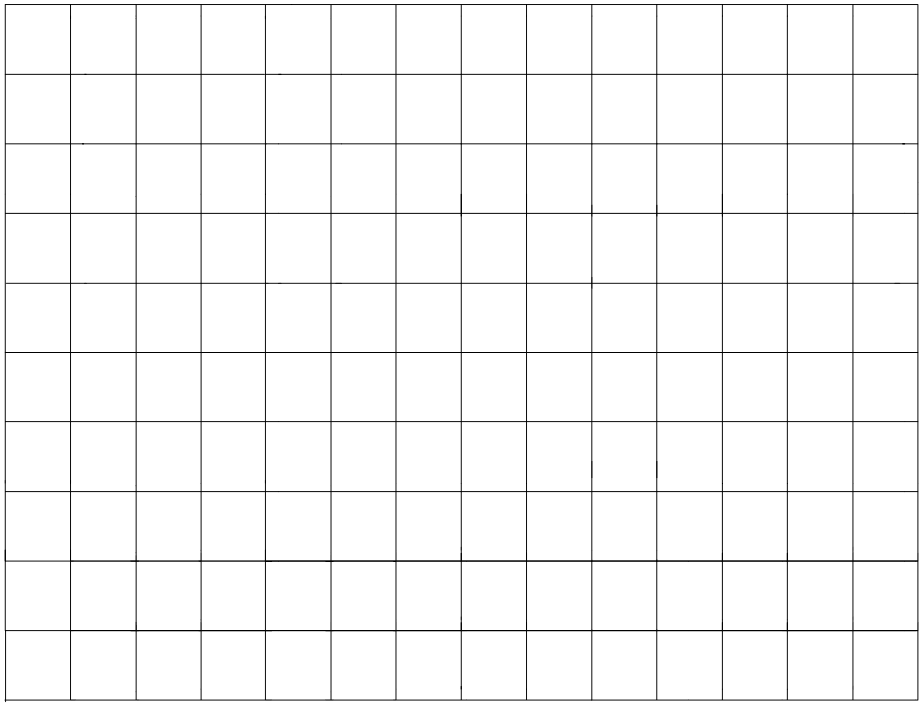
a. Exchange the 470 mH inductor for the capacitor in the circuit in Figure 2. Also change R_3 to R_4 = 10 kΩ and reset your frequency of the square wave to 500 Hz. You will be measuring v_L (t).

b. Measure v_L at each multiple of the "charging" cycle shown in Table 4 from Channel 2 of the oscilloscope. Use the value of τ determined in your prelab. Record your values in Table 4. You may need to adjust the time scale in order to make precise measurements. Carefully graph one full cycle of both waveforms on Graph 3.

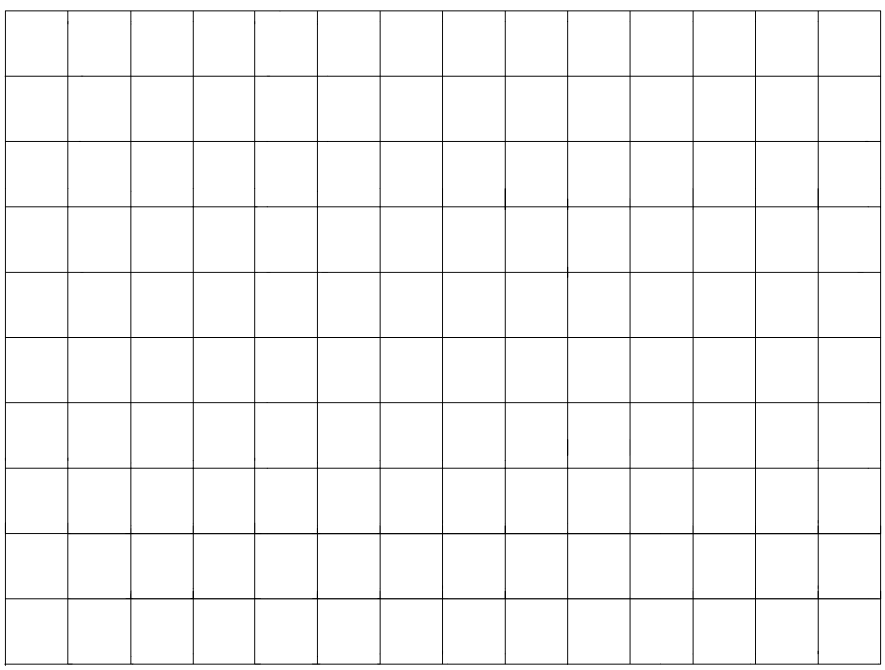
c. Change the frequency of the square wave to 8 kHz. Record the values for voltage in Table 4. Carefully graph one full cycle of both waveforms on Graph 4.

V_L(t) @	**τ**	**2τ**	**3τ**	**4τ**	**5τ**
500Hz					
8 kHz					

Table 4



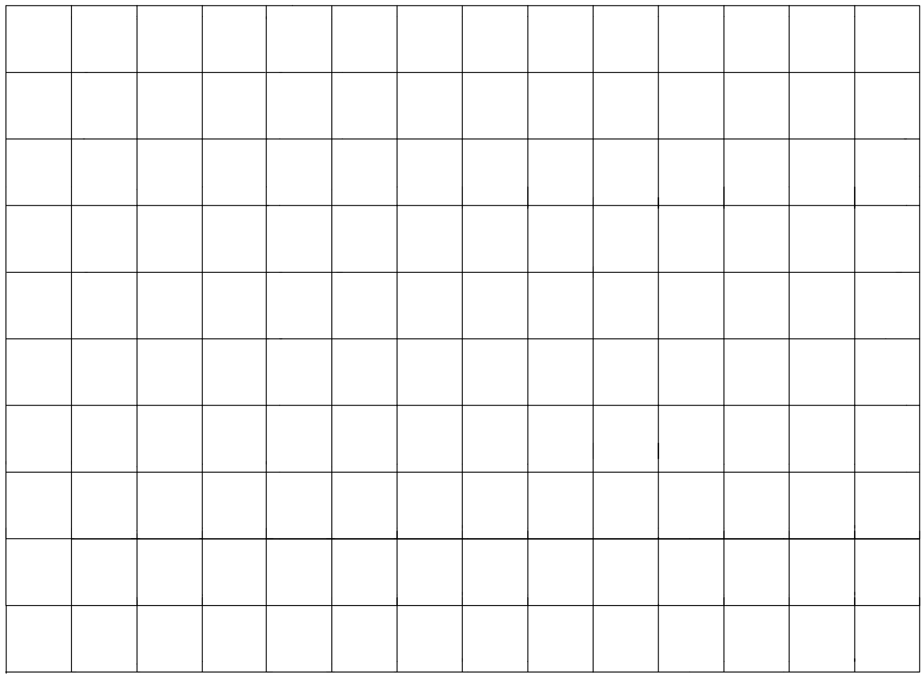
Graph 3
(L = 470 mH, freq = 500 Hz)



Graph 4
(L = 470 mH, freq = 8 kHz)

6. Questions

a. From your data in Table 2, carefully plot V_C versus time on Graph 5. Label both axes and include proper units. Indicate the intervals **1τ** through **5τ** on the horizontal axis.



Graph 5

Was the capacitor fully charged by 5**τ**?

b. For the circuit in Figure 2 with the frequency set to 500 Hz (graph 1), did the capacitor fully charge when the input voltage was at 4 volts? Explain.

c. For the circuit in Figure 2 with the frequency set to 4 kHz (graph 2), did the capacitor fully charge when the input voltage was at 4 volts? Explain.

d. For the circuit in Figure 2 with the frequency set to 500 Hz (graph 3), did the inductor fully de-energize when the input voltage dropped to 0 volts? Explain.

e. For the circuit in Figure 2 with the frequency set to 8 kHz (graph 4), did the inductor fully de-energize when the input voltage dropped to 0 volts? Explain.